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Rapport Report

Shrimp (*Pandalus borealis*) populations of Isfjorden and Kongsfjorden:

Effects of trawling and predators

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Akvaplan-niva AS
Fram Centre for Climate and the Environment
N-9296 Tromsø Norway
+47 7775 0301
http://www.akvaplan.niva.no

Shrimp (*Pandalus borealis*) populations of Isfjorden and Kongsfjorden: effects of trawling and predators

Forfatter(e) / Author(s)
Paul E. Renaud
Anne D. Andersen
Jørgen Berge

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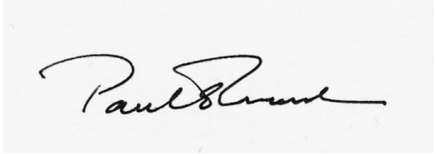
Sammendrag / Summary
Trawling appears to have little impact on shrimp (*Pandalus borealis*) population structure in Isfjorden when compared to untrawled Kongsfjorden. Population structure in the outer parts of both fjords are very similar, and reflect a greater proportion of older, larger stages than in the interior regions of either fjord. Size differences in middle and inner regions are not dramatic, and may very well be due to other factors, such as food availability, water temperature, and the relative ease of migration between habitats during different life stages. Predator density, which may also be strongly impacted by trawling, showed little variability between fjords in general, but did show significant differences among regions within the fjord: dominated by Atlantic cod in some areas, and large polar cod in others. Habitat use varies within the fjords, and management for this species should consider protection of nursery habitats in these fjords.

Prosjektleder / Project manager



Kvalitetskontroll / Quality control

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Preface

A preliminary survey of shrimp population structure in Isfjorden and Kongsfjorden in 2012 revealed counter-intuitive effects of fishery closure in Kongsfjorden. With funding from the Svalbardmiljøvernfund and other sources, this was followed up with a more extensive survey in 2013 during two cruises to the area. Results presented here are relevant for understanding population biology of an important species in the High North (the northern shrimp, *Pandalus borealis*), and impacts of environmental management strategies in the region.

1 Introduction

In a 2007 amendment to environmental regulations for Svalbard, Kongsfjorden and some surrounding areas were closed to shrimp (*Pandalus borealis*) fishing, including areas which since 2002 had been protected to ensure nursery areas for juveniles. Since then, only limited scientific trawling has been conducted in the area, while there has always been an active shrimp fishery in Isfjorden. Given this, it is reasonable to expect that after five years, it would be possible to see an effect of the protection, and the shrimp stock in Kongsfjorden would be different from that in Isfjorden, which has been subjected to a fishing throughout the five-year period . A preliminary study was therefore conducted with the permission of the Ministry of Fisheries in September 2012. The survey was conducted by collecting a random sample of shrimp from trawl catches in the two fjords, followed by weighing and measuring. We expected to find smaller and younger shrimp in Isfjorden, as we see in other areas exposed to chronic shrimp fishing (for example Oslofjord where the proportion of mature shrimp is very low) . The results, however, were striking and surprising, with distinctly larger and heavier (and therefore, most likely older) shrimp in Isfjorden compared with Kongsfjorden.

Whereas trawling can certainly lead to changes in population structure (size/age distribution, sex ratio), it can also affect predator populations, which may then lead to changes in shrimp populations. In addition, preliminary sampling was conducted only in the outer fjords, and it is uncertain whether these areas are representative of the fjords in general.

With funding from Svalbardmiljøvernfund, we then conducted a more intensive survey in the two fjords in autumn 2013 and asked the following questions: Are shrimp abundances and populations structures different in the two fjords? Is there spatial variability in population structure within and between fjords? and Can trawling or predator abundance explain the patterns observed?

2 Methods

Fig. 1 Map of stations sampled by trawling in Kongsfjorden and Isfjorden during two UNIS cruises in September-October 2013.

Sampling method

The data samples were collected between 19 August and 4 October 2013, on two research cruises on board R/V *Helmer Hanssen*. These cruises were conducted as part of courses at the University Centre of Svalbard (UNIS). Each cruise lasted two weeks and they were three weeks apart. The first cruise was part of the annual Norwegian-Russian Barents Sea ecosystem survey, jointly undertaken by Norwegian IMR and Russian PINRO. The station grid was area and depth stratified, and a total of seven stations were sampled in Isfjorden and Kongsfjorden. The second penetrated deeper into the fjords and sampled nine stations in the two fjords.

The bottom trawl used in the sampling was a Campelen 1800 shrimp trawl with rockhopper gear; the standard sampling gear employed in these surveys since 2005. It used a stretched mesh size of 80 mm in the front and 22 mm in the cod end. The horizontal and vertical openings were 17 m and 4-5 m, respectively, and the door spread about 45-50 m. The gear was towed at the bottom for approximately 15 minutes, at 3 knots/hour, covering a distance of approximately 0.75 nautical miles. However, due to the nature of the bottom, this time was reduced at four locations in inner Kongsfjorden. Using the trawl time and speed, distance was calculated and the catch weights and numbers were standardized to catch per nautical mile. At the majority of sites, CTD data was recorded using CTD-probes at 1 meter intervals from near bottom to the surface.

The trawl catches were sorted, weighed and measured. For taxa with large catches, such as shrimp and polar cod, random subsamples were taken. For fish, total length was recorded, either electronically using a fish board (first cruise), or manually (second cruise). For shrimp, the standard length recordings are of their carapaces; from the end of the eye opening to the posterior dorsal edge. This was done with an accuracy of 0.1 mm using Mitutoyo USB digital calipers, calibrated for each use.

Shrimp Subsampling

For shrimp, a random subsample of at least 400 individuals was taken at each station. Before being measured, they were first sorted according to maturity stages 2-8 based on the presence of sternal spines combined with the morphology of the endopodites on the first pair of pleopods (Mjanger et al 2006). More specifically, this included first separating the subsample according to presence or absence of roe. Using a Loupe, lamp and tweezers, the group without roe was subsequently separated into males (stage 2) and resting females (stage 7) based on the presence or absence of sternal spines on their abdomen. Assessing the morphology of the endopodites also identified a low number of intersex (stage 3) shrimp. The second large group comprised the spawning females. Females with abdominal roe (fertilised eggs) have already spawned and are classified as stage 5. It was not possible to determine whether these are first or second time spawners as the sternal spines were covered by eggs, and thus likely to already have had their appearance affected. The females with head roe were classified as either first (stage 4) or second time (stage 8) spawners based on the presence or absence of sternal spines. As expected, females with hatched eggs (stage 6) were not found.

Stomach Content Analysis

In order to assess potential predators of shrimp at this time of year, polar cod (*Boreogadus saida*) above 14 cm and other fish with a total length of more than 20 cm were analysed for stomach contents on the second cruise (nine stations). The potential predators studied meeting this condition included Atlantic (Northeast Arctic) cod (*Gadus morhua*), Greenland halibut (*Reinhardtius hippoglossoides*), long-rough dab (*Hippoglossoides platessoides*) and beaked redfish (*Sebastes mentella*). Within an hour after the trawl, the potential predators were identified, weighted and measured. The stomachs were carefully removed, labelled and placed in jars containing 70% ethanol. The fullness of the stomachs as a quartile percentage was noted. Analysis was carried out shortly afterward by placing the stomach on a petri dish, cutting it open with scissors and flushing out the contents with alcohol solution. Care was taken to identify and remove shrimp and other prey items swallowed in the trawl. Prey items were typically identified to family, genus or even species level, but decomposition sometimes made this impossible. Numerical and volumetric assessments of contents were noted to increase the resolution of the analysis, but contents were primarily recorded using the Occurrence Index (Hyslop 1980). Empty stomachs were excluded from the analysis.

3 Results and Discussion

Shrimp population size structure was similar in the outer areas of the two fjords but shrimp were larger in the middle and inner parts of Isfjorden than similar areas of Kongsfjorden. This is evident above (Fig. 2) as there is both a higher abundance of larger size individuals and a larger maximum size in Isfjorden. Habitat use by shrimp, then, appears to change during their life cycle, and amount of appropriate habitat for different life stages may vary between the two fjords. This can result in different total stock sizes between the two fjords, as well as different population structure.

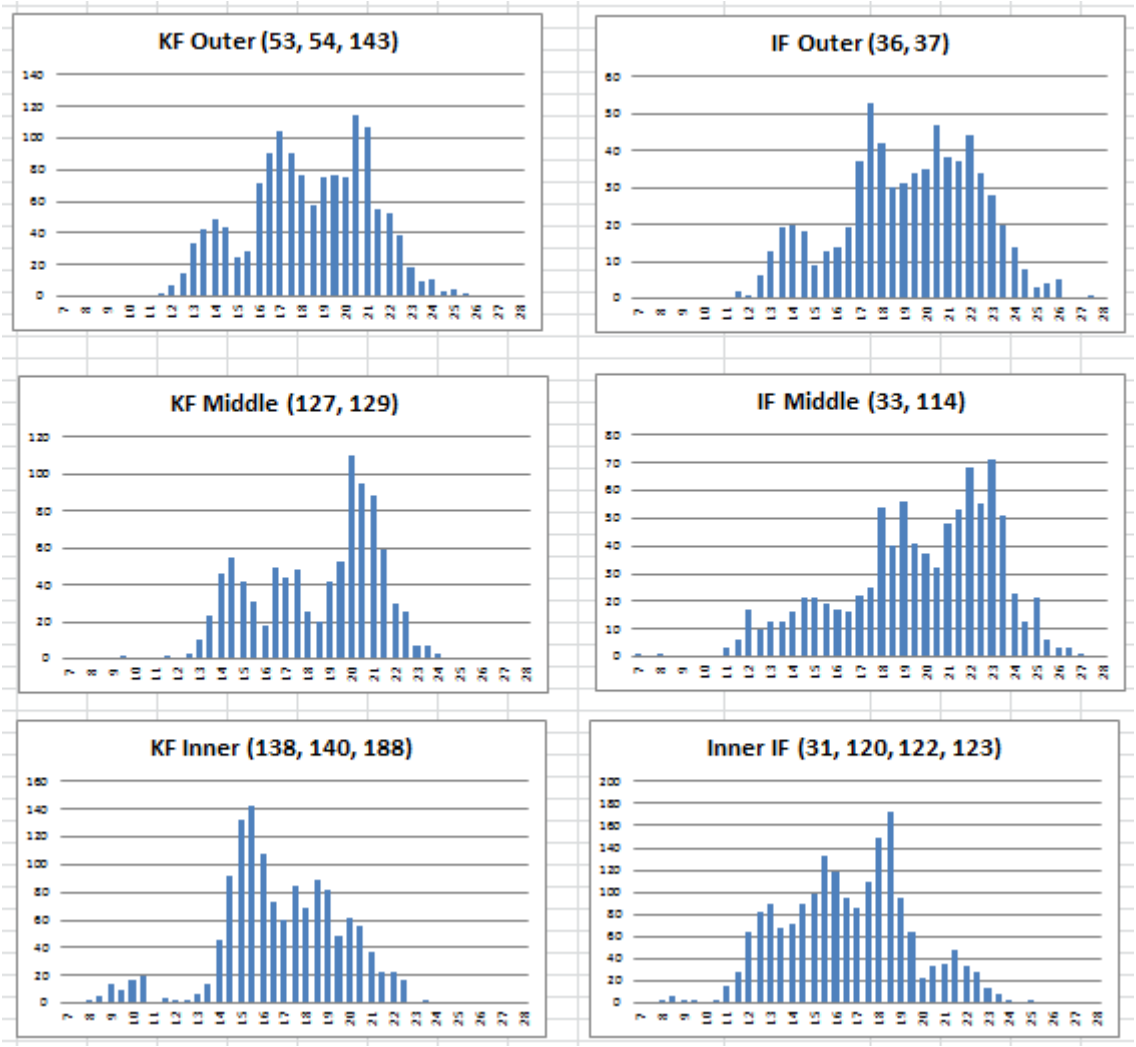

Fig. 2 Size frequencies of shrimp collected in outer, middle, and inner regions of Isfjorden and Kongsfjorden in 2013. Station numbers are indicated above the histograms. Note differences in vertical scales.

Sex ratios in the two fjords were nearly identical (Fig. 3). Shrimp are a protandrous species, meaning they are males when small then change to females at larger sizes (around 19mm carapace size in our study). The abundance of young males suggests good recruitment into each fjord. At all but one station the large majority of females were carrying eggs.

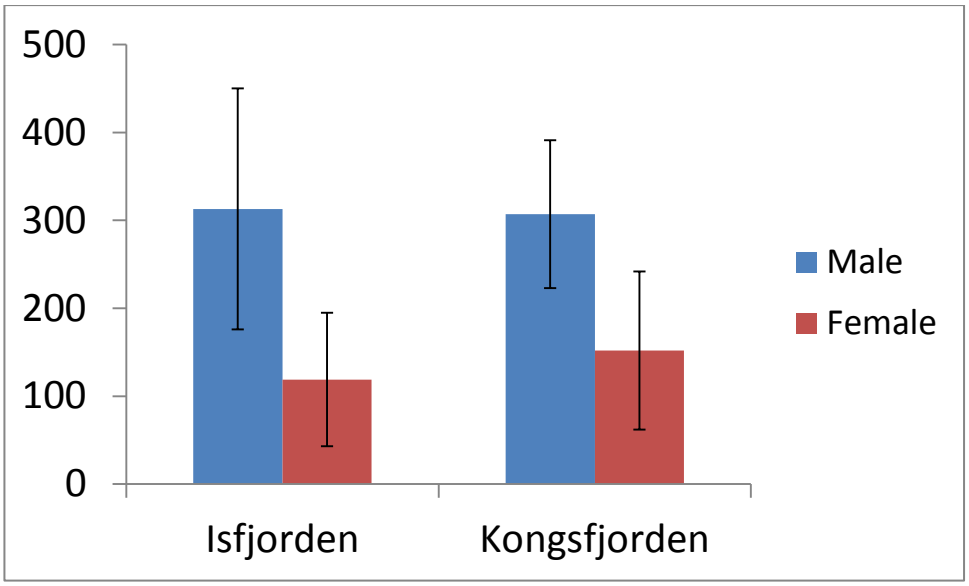

Fig. 3. Frequency of male and female shrimp from 8 trawls in each of the two study fjords. Bars represent 1 standard deviation.

Trawl sampling also revealed little significant difference in predatory fish abundance between Isfjorden and Kongsfjorden stations. There was, however, considerable variability among stations (Table 1). The most important predators of shrimp, based on stomach contents, were Atlantic cod (*Gadus morhua*: 28.8 and 42.4% in Kongsfjorden and Isfjorden, respectively), Greenland halibut (*Reinhardtius hippoglossoides*: 0 and 18.2%), and polar cod larger than 25 cm (*Boreogadus saida*: 10.9 and 9.7%). Other fish species examined included long rough dab (*Hippoglossoides platessoides)* and beaked redfish (*Sebastes mentella*). Personal observations by the project leaders suggest that abundance of large predatory fish, particularly Atlantic cod and haddock (*Melanogrammus aegelfinus*), was lower in 2013 than the previous 3-5 years. This perhaps results in underestimation of the effect of predators on shrimp population structure, since shrimp can live 8 years or more.

Species	**Isfjorden**	**Kongsfjorden**	
Gadus morhua	14.6 ± 14.5	27 ± 36.6	p > 0.4
Gadus morhua + *Reinhardtius hippoglossoides*	23.7 ± 14.0	29.3 ± 37.0	p > 0.7
Boreogadus saida	14.5 ± 12.2	295.8 ± 488	p > 0.17
All predators	70.6 ± 43.9	332.7 ± 476	p > 0.19

Table 1. Mean catch per nautical mile (± 1 SD) of potential predators of shrimp in the two fjords. P-values indicate no significant differences in the total predator abundance between the fjords, although considerable variability in polar cod catch was noted.

Summary and management implications

There is no evidence that trawling closure in Kongsfjorden (for more than 10 years now) has resulted in a dramatic change in shrimp population structure. Instead, shrimp in trawled Isfjorden are, if anything, larger than in untrawled Kongsfjorden. Abundances and size structure in the outer parts of both fjords are very similar. Size differences in middle and inner regions are not dramatic, and may very well be due to other factors, such as food availability, water temperature, and the relative ease of migration between habitats during different life

stages. Predator density, which may also be strongly impacted by trawling, showed little variability between fjords in general, but did show significant differences among regions within the fjord: dominated by Atlantic cod in some areas, and large polar cod in others. But this appears to have little direct impact on shrimp populations. This may well be due to relatively low trawling pressure even within Isfjorden.

Instead, structural differences in shrimp populations within the two fjords show different habitat use by shrimp during different life stages, and suggests that the relative abundance of nursery habitats within different fjords may be an important consideration when managing shrimp stocks around Svalbard. Further study is needed to develop clear mechanistic relationships among environmental variables, trawling, and shrimp population structure. Despite this, it already appears that management of shrimp in west Svalbard fjords must focus on protection of potential nursery habitats within the fjords.

4 Acknowledgments

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